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ECONOMIC ANALYSIS OF PCB DISPOSAL

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ECONOMIC ANALYSIS OF PCB DISPOSAL

INTRODUCTION

Fluids containing polychlorinated biphenyl (PCB) have been used in electrical equipment for many years. Recently, however, PCB has been found to be harmful to both humans and the natural environment. The Toxic Substances Control Act of 1976 banned its manufacture and distribution. Final regulations on the use and disposal of PCB were issued by the Enrivonmental Protection Agency on May 31, 1979. The EPA regulations permit the continued use of transformers and capacitors containing PCB and limited servicing of these transformers. The regulations require, however, that PCB stored for disposal prior to January 1, 1983 must be disposed of prior to January 1, 1984. Means of disposal is specified to be incineration in a facility of approved design.

PCB is defined by the new EPA regulation as chemical substances containing 50 ppm or greater PCB. There are currently over 1/2 million pounds of PCB in storage, mostly at Oak Ridge, which, as a consequence of the EPA ruling, must be disposed of by incineration prior to January 1, 1984. In addition, there are over 6 million pounds of PCB in transformers and capacitors at these ORO sites. This additional PCB will require the eventual disposal of over 13 million pounds of material (including the solvent used for cleanup) when the equipment is taken out of service. Some PCB wastes, such as those generated by spill cleanup in diffusion process buildings, may contain small quantities of enriched uranium. Even though there are only trace amounts, anyone handling this material must be licensed to handle enriched uranium. A summary of the applicable EPA regulations are provided as Appendix A.

A committee composed of representatives from K-25, Y-12, ORNL, Paducah, and Goodyear has investigated the PCB management problem and recommends that equipment containing totally enclosed PCB continue to be used. None of the commercial firms currently disposing of PCB waste is licensed to handle enriched uranium. Therefore, the committee also recommends that criteria and design be provided for EPA-approved incinerator facilities at one or more DOE sites.

The Paducah Engineering Division has prepared an engineering design basis and estimated the cost of PCB incineration systems. This design basis is included in this report as Appendix B.

The Operations Analysis and Planning Division was requested by the committee to undertake the economic analysis of PCB disposal alternatives.

The results of the analysis follow. It is pointed out that the OA&P analysis is limited strictly to the evaluation of economic trade-offs. Appropriate Environmental and Engineering groups were relied upon for cost information and guidance on constraints placed on economic trade-offs by safety and environmental considerations.

RESULTS AND CONCLUSIONS

The EPA regulations require that PCB liquids and waste stored for disposal must be disposed of by January 1, 1984. Future accumulations must be disposed of within one year. The regulations permit the continued use of totally enclosed PCB in transformers and capacitors which make up the bulk of the material at ORO sites. Timing for the eventual disposal of this totally enclosed material is very indefinite. Such equipment may be taken out of service because of failures, because of revised regulations, or because one or more of the GDP's is retired and the electrical equipment dismantled.

The quantities of PCB are summarized in Table 1 by site. This includes not only the material currently on hand but also the solvents needed to rinse transformers, shipping containers, etc., when the PCB is ready for disposal.

As can be seen from Table 1, the immediate problem is to provide incineration capacity to dispose of 581,000 pounds of liquid PCB in the "Stored for Disposal" category prior to January 1, 1984. In addition there are small quantities of solid PCB. These materials cannot be shipped to commercial disposal facilities because of the possibility of contamination with enriched uranium.

The Oak Ridge area is the only location that has been considered as an incinerator site because almost all the PCB currently stored for disposal is located at the K-25 and Y-12 plants. In addition, Oak Ridge has the largest total quantities of PCB and construction costs are less than at either Paducah or Portsmouth.

Two sizes of liquid incinerators have been evaluated, 2000 lbs/day and 4000 lbs/day facilities. The incinerators must meet the requirements of the EPA regulations which were issued May 31, 1979. As shown in Table 2, the 2000 lbs/day unit is capable of processing all the PCB stored for disposal in 10 months. Therefore, a facility of this size should be ready for startup by the first of 1983 in order to meet the disposal deadline of January 1, 1984. The larger 4000 lbs/day facility will require only 5 months to complete the initial disposal and therefore startup could be delayed until the middle of 1983. It has been estimated that the 2000 lbs/day facility will cost 90 percent as much as the 4000 lbs/day facility largely because the same extensive instrumentation will be required for each.

Table 1

SUMMAY OF PCB AT ORO SITES

	Transformers		Capacitors		Storage for Future Use		Storage for Disposal		Total Liquid	Total Solid	Total PCBs
	Gallons	Pounds	Gallons	Pounds	Gallons	Pounds	Gallons	Pounds	Pounds	Pounds	Pounds
ORNL - PCBs	8,465	97,000	-	-	70	1,000	-	-	98,000	5,000	103,000
Rinse Liquid	11,005	77,000	-	-	21	-	-	-	77,000	-	77,000
TOTAL - ORNL	19,470	174,000	-	-	91	1,000	-	-	175,000	5,000	180,000
ORGDP - PCBs	125,280	1,441,000	21,920	252,000	12,320	142,000	14,500	141,000	1,976,000	430,000	2,406,000
Rinse Liquid	162,864	1,140,000	-	-	3,696	26,000	4,350	30,000	1,196,000	-	1,196,000
TOTAL - ORGDP	288,144	2,581,000	21,920	252,000	16,016	168,000	18,850	171,000	3,172,000	430,000	3,602,000
Y-12 - PCBs	54,818	630,000	4,700	54,000	-	-	45,000	315,000	999,000	100,000	1,099,000
Rinse Liquid	71,263	499,000	-	-	-	-	13,500	94,000	593,000	-	593,000
TOTAL - Y-12	126,081	1,129,000	4,700	54,000	-	-	58,500	409,000	1,592,000	100,000	1,692,000
TOTAL OAK RIDGE	433,695	3,884,000	26,620	306,000	16,107	169,000	77,350	580,000	4,939,000	535,000	5,474,000
Paducah - PCBs	113,048	1,300,000	22,392	258,000	4,050	47,000	-	-	1,605,000	312,000	1,917,000
Rinse Liquid	146,962	1,029,000	-	-	1,215	9,000	-	-	1,038,000	-	1,038,000
TOTAL - PADUCAH	260,010	2,329,000	22,392	258,000	5,265	56,000	-	-	2,643,000	312,000	2,955,000
TOTAL UCC-ND	693,705	6,213,000	49,012	564,000	21,372	225,000	77,350	580,000	7,582,000	847,000	8,429,000
PORTSMOUTH - PCBs	160,490	1,846,000	25,154	289,000	43,500	500,000	75	1,000	2,636,000	436,000	3,072,000
Rinse Liquid	208,637	1,460,000	-	-	13,050	91,000	23	-	1,551,000	-	1,551,000
TOTAL - PORTSMOUTH	369,127	3,306,000	25,154	289,000	56,550	591,000	98	1,000	4,187,000	436,000	4,623,000
TOTAL ORO	1,062,832	9,519,000	74,166	853,000	77,922	816,000	77,448	581,000	11,769,000	1,283,000	13,052,000

Askarel - 11.5 lb/gal
Oil & Rinse Liquid - 7 lb/gal
Solids - 5% of Liquid plus capacitor carcasses at 25 lb each

Table 2

COMPARISON OF PCB DISPOSAL FACILITIES
Located at Oak Ridge

(FY 1984 Dollars)

	Alternative 1	Alternative 2
Liquid PCB Capacity	2,000 lbs/day	4,000 lbs/day
Capital Cost	$2,845,000	$3,161,000
Operating Cost	70¢/lb	40¢/lb
Short-Term PCB Disposal (Prior 1/1/84)		
Quantity	581,000 lbs	581,000 lbs
Operating Cost	$407,000	$232,000
Shipping Cost	0	0
Total Cost	$3,252,000	$3,393,000
Disposal Period	10 months	5 months
Complete PCB Disposal		
Quantity	13,052,000 lbs	13,052,000 lbs
Operating Cost	$9,136,000	$5,221,000
Shipping Cost	$379,000	$379,000
Total Cost	$12,360,000	$8,761,000
Disposal Period (All PCB)	20 years	10 years
Disposal Period (All PCB from 1 GDP)	4 to 7 years	2 to 3 years

Operating costs for the small system are estimated to be 70¢/lb compared to 40¢/lb for the larger unit primarily because the same labor force will be required for each. The total short-term disposal cost (capital plus operating) will be $3,252,000 for the small unit compared to $3,393,000 for the larger, a difference of only 4 percent. The breakeven point would be reached when a total of 1,050,000 pounds had been incinerated.

Only small quantities of solid PCB waste are expected initially. Therefore, the solids incinerator should be of the minimum size that will meet the EPA requirements and be capable of disposing of capacitor carcasses. After the initial period of operation, the facility, under present PCB regulations, would be needed only occasionally to dispose of additional PCB from Oak Ridge, Paducah or Portsmouth. It could then be used to dispose of PCB from other DOE sites and would probably be capable of disposing of other hazardous materials.

In the event of regulations prohibiting use of PCB, the 4000 lbs/day facility would be capable of disposing of all PCB at the 5 installations in less than 10 years or all PCB at a single GDP in less than 3 years. Each of these times would be double for the 2000 lbs/day facility. Therefore, for a relatively small additional investment the larger unit could be constructed and it might eliminate the need to build a second incinerator at some future date.

DISCUSSION

QUANTITY OF PCB FOR DISPOSAL

The quantity of PCB that is currently on hand and the amount that will be generated for disposal at each ORO installation is summarized in Table 1. This table includes an allowance for a solvent to rinse the transformers when they are retired and to rinse the shipping drums prior to reuse or disposal.

It is estimated that solid PCB waste will amount to 5 percent of the liquid PCB plus the capacitor carcasses. Much of this solid waste will be generated during disposal of the liquid PCB and will consist of rags, gloves, sawdust, as well as the capacitor casings.

The column labeled "Storage for Disposal" lists the material which must be disposed of prior to January 1, 1984. This is currently estimated to be 581,000 pounds.

The timing for disposing of the PCB remaining in use, over 12 million pounds including solvent rinse, is very indefinite. Past experience with transformers and capacitors at the three diffusion plants indicates a very low failure rate. However, this equipment has been in service for 25 or more years and even though many transformers have been upgraded some failures can be expected. Disposal of large quantities of PCB will be necessary should one or more GDP be phased out of service and dismantled.

The fact that some PCB contains small quantities of enriched uranium creates disposal problems. No commercial PCB disposal firm is authorized to handle enriched uranium and none have indicated an interest in obtaining the necessary licenses. Therefore, even though the amounts of enriched uranium are relatively insignificant, it will be necessary for ORO to provide incineration facilities. It is expected that all uranium will be removed from the gas stream in the scrubber and become an insignificant amount of the sediment in the holding pond.

ASSUMPTIONS

1. The quantities of PCB which will require disposal are summarized in Table 1.

2. Conceptual design for a facility capable of disposing of 4000 lbs/day of liquid PCB and 50 to 100 lbs/hour of solid waste containing PCB was prepared by Paducah Engineering. The design basis is included in the Appendix.

3. A 4000 lb/day disposal facility is estimated to cost $3,516,000 in FY 1984 dollars at Paducah. Based on recent construction indices, similar facilities would be expected to cost 2 percent more at Portsmouth and 10 percent less at Oak Ridge.

Location	Index	Cost
Portsmouth	100.4	$3,598,000
Paducah	98.1	3,516,000
Oak Ridge	88.2	3,161,000

4. It has been estimated that it will cost 10 percent less to construct a facility of 2000 lb/day liquid capacity.

5. Operating cost of a 4000 lb/day facility will be 40¢/lb. A 2000 lb/day facility would cost 70¢/lb to operate. The principal cost elements are labor, overhead, utilities, lime, activated carbon, and some fuel oil.

6. The facility would operate 24 hours/day, 7 days/week, 11 months/year if sufficient material is available for disposal.

7. After emptying, each shipping drum will be flushed with a solvent equal to 30 percent of the volume of the drum. Each transformer must also be rinsed with solvent. The solvent must also be incinerated.

8. Interplant shipments will cost $5/cwt. This is approximately 2 1/2 times the normal shipping rate but will permit extra precautions to reduce risk of accident. It will also cover the cost of returning empty drums.

APPENDIX A

SUMMARY OF EPA REGULATIONS

The Environmental Protection Agency issued final regulations on the use and disposal of PCB on May 31, 1979. The most pertinent points are listed here.

DEFINITIONS

PCB is defined as any chemical substances and combination of substances that contain 50 ppm or greater of polychlorinated biphenyls. Substances that contain less than 50 ppm PCB because of dilution must also be classified as PCB.

PCB Transformer refers to any transformer containing 500 ppm or greater PCB.

PCB Contaminated Transformer refers to any transformer containing 50 ppm or greater but less than 500 ppm PCB.

Small Capacitors contain less than three pounds of dielectric fluid.

PCB Container refers to any container whose surface has been in contact with PCB.

PCB DISPOSAL REQUIREMENTS

a) The final EPA regulations require that almost all substances with 500 ppm or greater concentration of PCB must be disposed of in an approved incinerator. Some materials with concentrations of less than 500 ppm PCB may be disposed of by other means. However, it appears that almost all PCB at the three ORO sites should be destroyed by incineration.

b) The PCB in transformers and capacitors is classified as "totally enclosed" and may continue in use until the equipment is retired from service.

c) When a PCB transformer is removed from service, it will be necessary to drain the fluid, fill the transformer with a solvent and allow it to stand for at least 18 hours. Both the PCB and the contaminated solvent must be disposed of by incineration.

d) PCB transformers, which by definition have contained 500 ppm or greater PCB, may be disposed of by incineration or in EPA-approved chemical waste landfills after they have been drained and rinsed in the specified manner.

e) Small capacitors may be disposed of in municipal landfills, although large users are expected to dispose as PCB waste. No effort needs to be made to locate PCB capacitors in light fixtures.

f) Large capacitors must be disposed of by incineration after January 1, 1980.

g) Non-liquid PCB may be incinerated or disposed of in an approved chemical waste landfill.

h) Any PCB that is stored for disposal prior to January 1, 1983, must be disposed of by January 1, 1984. New accumulations must be disposed of within one year of entering storage.

i) PCB can only be shipped in EPA-approved drums.

APPENDIX B

DESIGN BASIS FOR PCB INCINERATION SYSTEMS

The following conditions will have to be designed into any PCB's incineration system. Conditions for adequate combustion are a two-second dwell time at approximately 2000°F with three percent excess oxygen in the stack gas or a one and one-half second dwell time at approximately 2700°F with two percent excess oxygen in the stack gas. Combustion efficiency, which is $(C_{CO_2}-C_{CO})/C_{CO_2} \times 100$, shall be at least 99.9 percent. Verification of such operation will be through extremely stringent monitoring and record keeping programs. Included will be continuous monitoring of O_2 and CO in the stack gas. In addition, periodic monitoring of NOx, hydrocarbons, PCB's, CO_2 and HCl will be required to ensure compliance with applicable ambient air standards and continuous measuring and recording of the incinerator temperature. Records relating to the amount of PCB's material being incinerated will be required on a 15-minute basis. The incinerator operations shall be immediately suspended when any of the above conditions fail.

The PCB disposal facility will contain two incineration systems; one system to incinerate liquid PCB's and the other system to incinerate solid waste contaminated with PCB's. The liquid system will incinerate 170 lbs/hour of liquid PCB waste and the solid waste system will incinerate approximately 50-100 lbs/hour of solid waste.

Liquid PCB will be stored in two 5,000-gallon storage tanks and fed by metering pumps to the incineration system from two 500-gallon feed tanks. The liquid PCB will be incinerated in a horizontal, refractory lined incinerator at an operating temperature of 2400°F. The incinerator will be approximately 5' O.D. x 10' long. The liquid PCB waste will be atomized with steam and fed into the incinerator through a combination fuel oil and liquid PCB burner. The incinerator will be preheated to the operating temperature with fuel oil before starting the liquid PCB feed. The hot corrosive gases that are produced from the incineration process will pass through a process gas cooler (2.5' O.D. x 16' long), where 1,400 lbs/hour of 100 psig steam will be generated and recovered. The corrosive gases will then pass through a 2' O.D. x 30' high vertical packed column scrubber designed to remove 99 percent of HCl present in the gas stream.

Neutralization of the HCl produced will be accomplished by the addition of lime. The neutralization system will consist of a storage hopper for lime, lime slaker and feeder, slurry tank, transfer pumps and a 600-gallon neutralization tank. The attached drawing M5E-14896, Revision A, shows the proposed equipment layout plan for the liquid PCB disposal system.

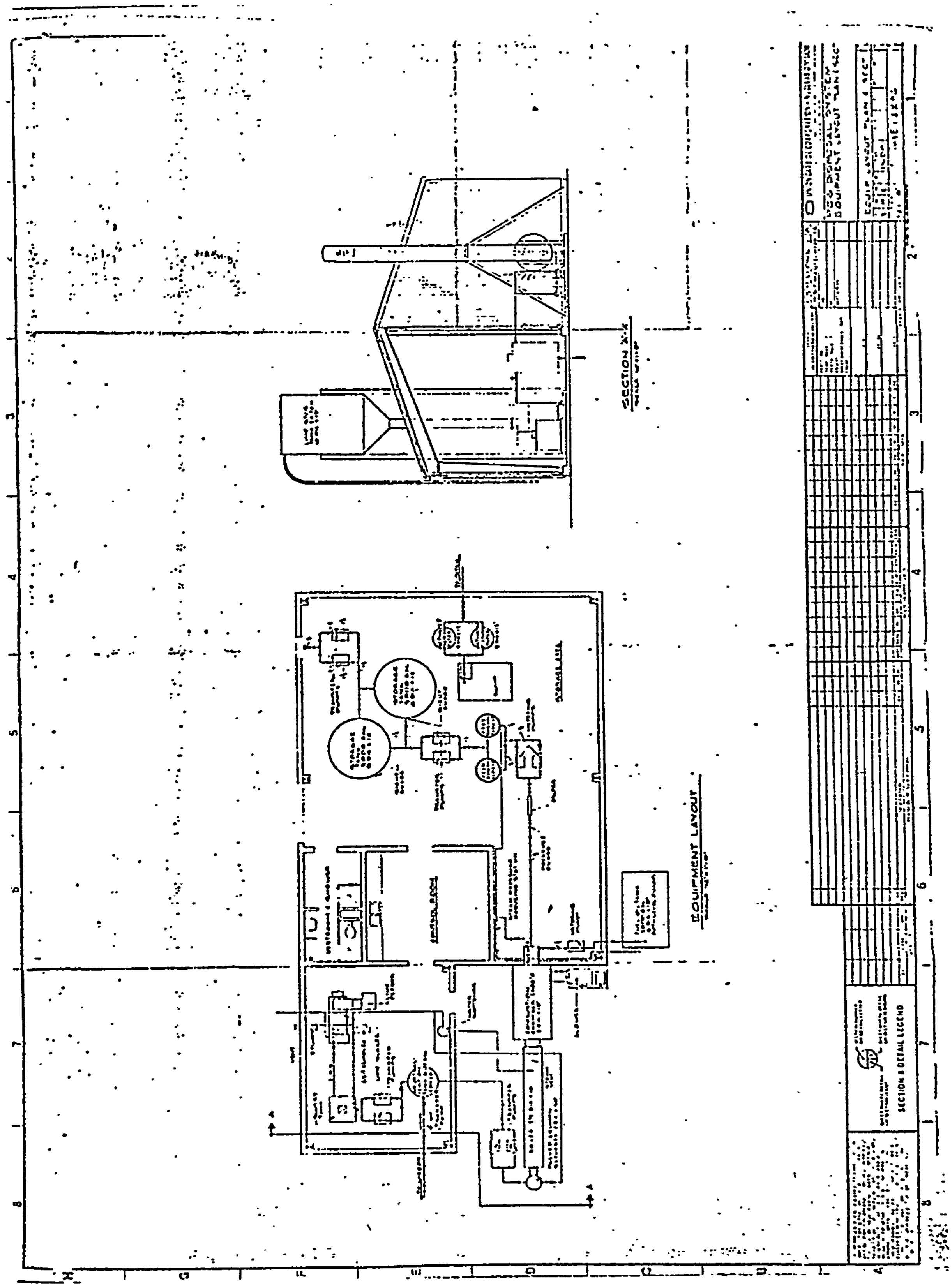
Solid waste contaminated with PCB will be initially stored in 55-gallon drums before being fed into the incineration system. The solid waste will be fed from the 55-gallon drums by a forklift and drum dumper, into the rotary kiln incinerator. The rotary kiln incinerator consists principally of a revolving refractory lined cylinder, slightly inclined to the horizontal, supported by two riding rings resting on two trunnion rolls. The rotary incinerator will be approximately 5' O.D. x 15' long, natural gas fired and operate at a temperature approximately 2000°F. A ram type feeder will be used for feeding solid waste into the rotary chamber. The combustion gases will then pass through an afterburner chamber, which is also gas fired and operated at 2000°F, to incinerate any PCB's remaining in the exhaust gas. Following the afterburner, the exhaust gases are cooled by water in a precooling chamber before entering the scrubber. A wet scrubber system will be used to remove any particulate matter from the exhaust gas and also remove any HCl from the gases. The dilute HCl solution from the scrubber will be neutralized with lime in the same neutralization system described before. The attached sketch shows the proposed solids incineration system. Drawing M5E-14896, Revision A, does not show at this time the proposed layout of the solid waste incineration system.

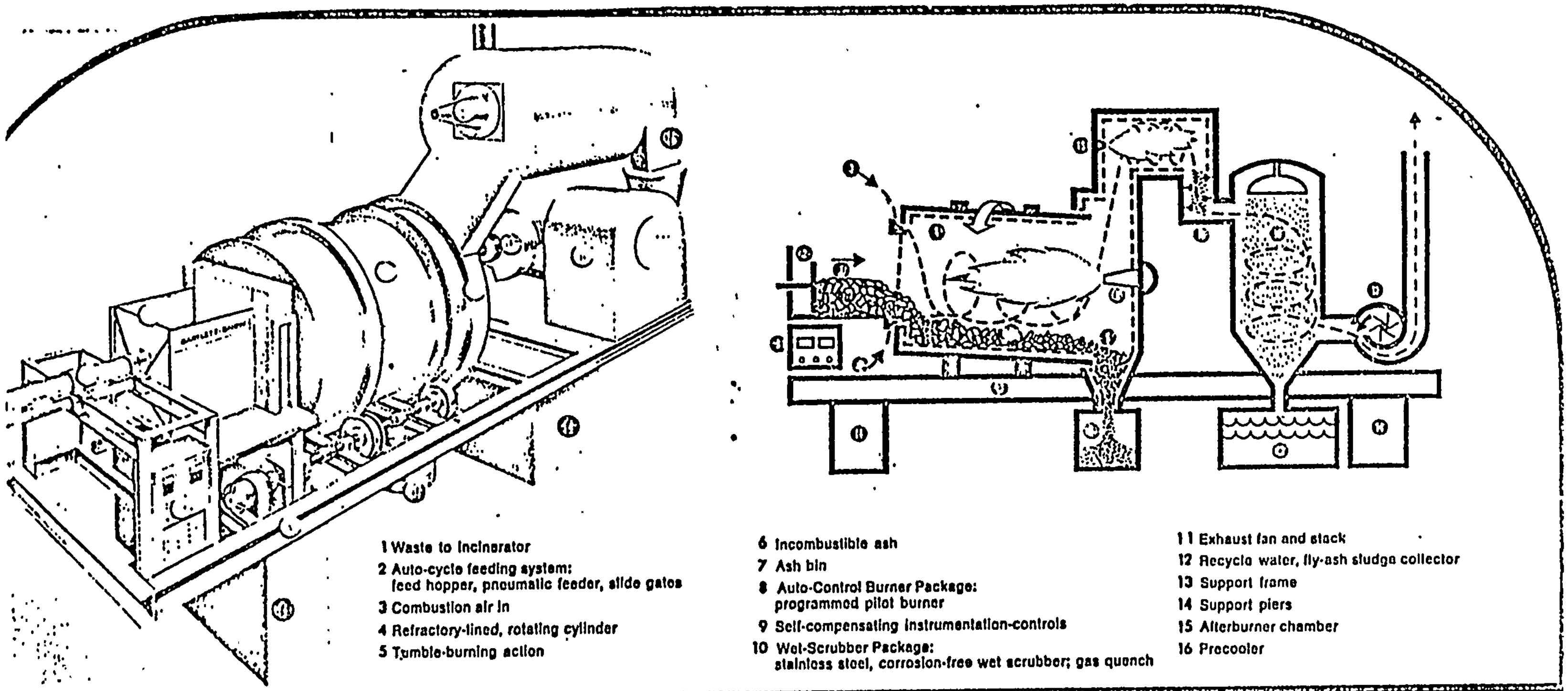
Instrumentation for the incinerator facility will consist of O_2, CO_2 and CO analyzers, temperature controller/recorder, pH monitor and controller and a gas chromotograph. A mini-computer will be used to obtain all the necessary data to meet EPA requirements and also control the critical parameters of the process, and any system failure that may occur.

A building will enclose all equipment that comes in contact with PCB or the neutralization system. The floor in the building will be completely curbed to contain any PCB spills. All floor drains will flow to a sump located inside the building. Water contaminated with PCB's from the sump will be pumped through two activated carbon filters to remove any traces of PCB before being dumped into the sewer system. Drains from showers and wash facilities will also be routed through the activated carbon traps.

Sanitary water will be required for washrooms, safety showers, eye washes, drinking fountain and fire protection. Plant water will be required for the neutralization system, gas coolers and scrubbers. Other utilites, such as steam and dry air, will be required. Steam will be necessary for building and tank heating and for steam atomizer in the liquid PCB incinerator. Dry air will be required for air-operated instrumentation and pneumatic valve operators. Electrical facilities to supply 460, 230, and 115 volts will be necessary for operating functions. An area for a maintenance shop will be needed for system maintenance. Laboratory facilities will be necessary for on-site testing and analyses. Adequate rest rooms, showers, lunchroom and office facilities will also be needed.

The cost estimate for the liquid PCB system in 1978 dollars is $1.7 million. This cost does not include the cost for bringing utilities to the building, since no site commitment has been made. The vendor cost estimate for the solid waste incineration system is $110,000. This cost does not include installation, solid waste feeding system and a building to house the solid waste system. There is a possibility that the two systems can be combined into one system by using the liquid incinerator as the afterburner chamber in the solid waste incineration system.


SECTION 'A-A'
EQUIPMENT LAYOUT


1 Waste to incinerator
2 Auto-cycle feeding system: feed hopper, pneumatic feeder, slide gates
3 Combustion air in
4 Refractory-lined, rotating cylinder
5 Tumble-burning action
6 Incombustible ash
7 Ash bin
8 Auto-Control Burner Package: programmed pilot burner
9 Self-compensating instrumentation-controls
10 Wet-Scrubber Package: stainless steel, corrosion-free wet scrubber; gas quench
11 Exhaust fan and stack
12 Recycle water, fly-ash sludge collector
13 Support frame
14 Support piers
15 Afterburner chamber
16 Precooler